11. The structure of the ramified and net-like configuration of the viscid substance depends chiefly upon the degree of force of the rotating mantle-fluid, the form of the cellulose capsule, the point of attachment of the viscid mass on the cellulose capsule and its relative position to the axis of rotation of the mantle-fluid, and, lastly, upon its state of cohesion.

12. There is no essential difference between the rotating, circulating, and rotato-circulating currents of the cells; in all, the rotating mantle-fluid is to be placed in the foreground; in it alone we can recognize the direct influence of the unknown causes of the currents, and this everywhere acts in the same way.

13. The other constituents of the "mantle-layer" exposed to the mechanical influence of the rotating mantle-fluid cause the current of the vegetable cell to vary in outward appearance; they will also, of course, present varying obstacles to it according to circumstances. Among the phenomena of this nature I may indicate that in the cavities formed between the resting masses of the viscid substance the rotating mantle-fluid may come to perfect rest, and that then molecular movements of free granules are detected in such cavities,—further, that in *Hydrocharis morsus ranæ* the rotating mantle-fluid is divided into two regular rotating currents, running down separated from each other by a distinct piece traversing the cavity of the cellulose capsule,—and, lastly, that by means of such impediments at the rounded poles of the cellulose capsule reflux movements of the currents of the most various kinds may be produced.

14. Motory phenomena from which the existence of a contractile activity in the viscid substance or in the other constituents of the cell-contents might be deduced, are entirely wanting in the plant-cells with currents investigated by me.

15. With regard to the movements of currents in the cells of plants, the first thing to be done is to discover the causes by which the rotating movements of the "mantle-fluid" are produced. But no physical or chemical processes by which this rotating movement might be brought about have hitherto been detected in the cells of plants.

IV.—*Conclusive Proofs of the Animality of the Ciliate Sponges, and of their Affinities with the* Infusoria flagellata. By H. James-Clark, A.B., B.S.*

Before I proceed to the main point in question in this article, I wish to say a word in regard to the group of animals, viz. the Protozoa, of which I am fully convinced the *Spongiæ ciliatæ* are a part.

* From 'Silliman's American Journal, Nov. 1866.

From the time when Ehrenberg published his great work the 'Infusionsthierchen,' to the period of the issue of the 'Études sur les Infusoires' of Claparède and Lachmann, there has been a steadily growing belief that a large part of that mass of animalcules which Ehrenberg denominated *Infusoria* forms a distinct grand division, quite as decided in character as any of the four great groups which are now generally accepted. Still it is a little curious that, although Cuvier had long ago pointed out the *plan* or type upon which his four *embranchements* were constructed, later investigators have not attempted to elucidate the *typical idea* which lies at the basis of the Protozoan organization. Claparède and Lachmann have approximated nearest to such an attempt, in their division of a part of the group into dexiotropic and læotropic sections; but nothing is said even by them of a plan which runs through the whole grand division. Surely they had seen enough of material, at least of the higher divisions of the group, to sustain them in pronouncing upon the typical relation of the Infusorial organization; but it may be that the apparent paucity of characters among the lower members of this grand division misled them into an apprehension that there was no definite taxonomical relationship of the organs. That they recognized the latter as members of the same group with the former, no one will deny; but it must be conceded that the affiliation was observed to be only one arising from similarity of organization and habit, and not from any community of *plan* in the disposition of the organs.

It is now over two years since I demonstrated (in a course of lectures, delivered in February and March, 1864, at the Lowell Institute in Boston) that the arrangement of the organization of the Protozoa is based upon a spiral or, rather, a helix: more recently those lectures have been published*, and the *type* of the organization of the Protozoa, as well as that of each of the other four grand divisions of animals, made as clear by illustrations as the limits of the volume seemed to allow. In order, therefore, that I may not appear to claim for the Sponges merely a new position in the universe of obscurities, I shall take the liberty of drawing the reader's particular attention to the arguments which I have adduced, in the volume above mentioned, to prove the unity of plan in the organization of the Protozoa and its dissimilarity from any other which dominates among the four remaining grand divisions.

This much being premised, I proceed now to give a sketch of the peculiarities of some of the genera of Infusoria flagellata with which I think the Sponges are most intimately associated.

* H. James-Clark, 'Mind in Nature.' D. Appleton & Co., New York, 1865.

Several of these genera are new to science, and, moreover, of the most remarkable forms. I regret that words alone cannot, at this time, render their peculiarities as evident as I hope the illustrations will in my forthcoming paper in the 'Memoirs of the Boston Society of Natural History.'

I must ask the reader, in the first place, to go back with me almost to the Ultima Thule of animal simplicity, and revise the organization of the hitherto too lowly estimated *Monas*, in order to lay the foundation for the group which embraces in its limits so gigantic a family as the Spongiæ ciliatæ. I do not think any one will be prepared to fully appreciate such a remarkable definiteness and system in the arrangement of the organization of *Monas* as I have discovered among the various forms which constitute that genus.

Hitherto a *Monas* has been looked upon as a mere shapeless molecule, with a vibrating *cilium* of some sort or other, attached to its surface at an indefinite point. As I understand the relation of parts now, the *motory cilium* or *flagellum* is perhaps the most remarkable feature of the whole animal, not only in a physiological aspect, but also in its topographical relationship. Let me illustrate this by a description of the body and appendages of *Monas termo*, Ehr.

The body of that species has the form of a wide, compressed heart, with two distinct summits. The broad flattened sides lie opposite to each other, and parallel with the plane which passes through the two summits, and which forms the prolongation of the greater transverse diameter of the body. Between these summits is an aperture which constitutes the mouth. One of the summits is prolonged into a broad, conical, beak-like body, and assists the mouth in the prehension of food. It is therefore a true *lip*. The *flagellum*, however, is the real prehensory organ, although it, at the same time, performs the office of a propelling agent when the body is detached from its pedicel and moves about in a free state. This organ has the form of a scarcely tapering bristle, which is attached close to the edge of the mouth, on that side of it which is opposite to the lip, and rises with a decided well-defined curve whose plane is coincident with the plane which runs through the two summits, and forms, as I have just mentioned, the plane of the greater transverse diameter of the body. This remarkable feature is scarcely to be recognized during the free state of the animal; but when the latter is moored by its posterior end to its pedicel, the phenomenon in question is very marked and conspicuous. For most of the time the *flagellum* sustains itself in this rigid arcuate position, and is always curved away from the lip; but its terminal end keeps up an

almost incessant spasmodic incurvation toward the mouth, to all appearance for the purpose of throwing or jerking particles of food in that direction. When an acceptable morsel is met with, both the lip and the flagellum combine to press it into the open jaws of the animal; and when that is accomplished, the two organs immediately return to their former positions.

Scarcely less noticeable is the so-called *contractile vesicle*—the analogue of the heart of the higher animals. In a view of the body so placed that the lip is next the eye, and the flagellum consequently curving away from the observer, we have the two broad sides on the right and left, and the plane of the greater transverse diameter coincident with the line of vision. The body then seems, at first sight, to have a symmetrical aspect, such as is not observable from any other point of view; and such it might be made to appear if I should belittle the importance of one single organ, by simply mentioning its existence and omitting to lay down its exact topographical relationship. I refer to the *contractile vesicle.* During the systole of this organ it is so inconspicuous that it would easily escape even the most careful observation; but during the transition to the expanded state, and at the full diastole, its prominence, from the point of view just mentioned, is so great as to rival the flagellum in attraction. It may then be seen as a comparatively large, rounded, transparent, vesicular body, which stands out in strong profile, just in front of the middle, and close to the surface of the left side of the body. At full diastole it even forces the overlying region outwardly into a quite prominent papilla. In reference to the other organs and parts of the body, it stands, therefore, altogether in an asymmetrical relation; and from whatever point of view it, or any of the organs, may be observed, the organization as a whole evidently rests upon an oblique basis. The *bilaterality* of the type is sufficiently clear; but the topographical relationship of the organs is incompatible with *bisymmetry,* for right and left are twisted upon each other.

So much for *Monas.* As for the objection which has been raised against the estimate that has been put upon the monad-like Infusoria, because they have not been proved to be adult forms, it seems to me that the *onus* of proof lies on the other side, viz. to show that they are not adult. I think, moreover, that I am fully warranted in assuming that a *Monas* which possesses such an organization as I have described, and is attached to a stem, is an adult; and more especially so since, among many hundreds which I have observed from time to time, I have never seen any trace of a transition to a higher form. That such simple organizations can exist without rising to a more compli-

cated state during a whole lifetime, I am furthermore sustained in believing by the discovery of some new generic forms, which, although scarcely, if at all, more highly organized than *Monas*, have in addition such characters as would seem to stand in the way of a transition to a more elevated grade of existence. For instance, the presence of a *calyx* about the body of an infusorian, into which it can retreat, is an indication of a fixity of condition which corresponds to the adult state. Thus I found one of the new genera which I have just alluded to.

Bicosœca, as it is called, may be described in general terms as a stemless *Monas* which is attached to the bottom of a calyx by a highly muscular retractile cord. All the organs have the same remarkable definiteness of relationship and peculiarity of form that *Monas* possesses; and in addition there is the muscular cord which with oft-repeated jerks retracts the body to the very bottom of the calycine envelope. There are two singularly diverse species of this genus—one marine, and the other lacustrine.

The most interesting infusorian of this group of new forms is the one which I have called *Codosiga*. This links the Sponges to the flagellate Infusoria. Its greatest peculiarity consists in the possession of a highly flexible, extensible and retractile, membranous collar or hollow cylinder, which projects from the anterior end of the body. The cylinder is slightly flaring; and if we include the asymmetrical body, the whole might be compared to a very deep one-sided bell, with its narrower end half filled up. The single, sigmoid-arcuate, rigid flagellum arises from the depths of the bell, exactly at the middle of the truncate front, as it were forming a prolongation of the longitudinal axis of the body. There is no lip; and the flagellum, which rises close to the mouth, has a strong resemblance to that of *Monas*, both in proportion, form, and habits, and performs the office of a prehensile organ when the body is fixed, or acts as a propeller during natation. The *contractile vesicles* are two, or even three, in number, and lie in the posterior third of the body. The only species of this genus which I know of is gregarious in habit; but usually not more than four or five bodies are to be found attached, like *Anthophysa*, by their narrower posterior ends, to the branchlets of a single forking stem. The peculiarity in regard to the direction of the curvature of the flagella in a backward direction toward the stem, is as highly marked in *Codosiga* as in *Anthophysa* (described by me in the Number of the 'Annals' for December, 1866); and there is also the same fixed relationship of the longitudinal and the greater and less transverse diameters of the several individuals of the colony.

There is still another new genus which I should like to men-

tion here, because it forms a collateral link with *Codosiga* in the affiliation of the Sponges with the *Monadina*. This genus I have called *Salpingœca*. It is, as it were, a single individual of *Codosiga*, which does not possess a stem, but is seated in a *calyx*, from which it protrudes, or into which it retracts, at will. There are three well marked species, of which one is marine.

I now come to the principal object of this communication. The sponge which formed the main basis of these investigations is the well-known marine species, *Leucosolenia* (*Grantia*) *botryoides*, Bowerbank. It is preeminently a branching form, and, on account of the slenderness and transparency of its tapering, hollow ramules, is a most desirable object for study. A branchlet, and, in fact, the whole colony, may be stated to be essentially a double tube. The outer tube consists of a glairy, gelatiniform stratum in which the spicules are imbedded in a certain order, and is pierced by numerous ostioles, which are continued through the interior tube to its hollow centre. The inner layer or tube is entirely made up of the individual members of the colony, the bodies of which are packed together closely, side by side, like pavement-stones, with their posterior ends slightly imbedded in the glairy substance of the outer tube, and their anterior ends projecting freely into the general cavity. To describe the shape and organization of one of these individuals would be to repeat, almost word for word, what I have already said of the monad of *Codosiga*; in short, *Leucosolenia* bears some such sort of relationship to *Codosiga* as *Salpingœca* does, the latter being, as it were, a stemless *Codosiga* seated in a calyx, whilst *Leucosolenia* is comparable to a stratum of the monads of *Codosiga* imbedded in a spiculiferous envelope. It is clear therefore that the organic difference between *Leucosolenia* and *Codosiga* is scarcely enough to locate them in two different families; in fact, I am inclined to regard them as only generically distinct, and hardly, if at all, more widely separated in this respect than are *Salpingœca* and *Codosiga*.

What are the diversities of other genera of the Spongiæ ciliatæ I cannot more than conjecture; but seeing that one of the genera is so closely related to the monociliate flagellata, it can hardly be possible that the others are very far removed; and I shall feel warranted, therefore, in assuming, upon the premises, that the whole group of Spongiæ ciliatæ is as intimately allied with the monociliate Infusoria flagellata as it is possible for it to be without actually constituting with the latter a uniform family.